Self Declaration

The research scholar is solely responsible for representation and interpretation of the contents of the papers compiled in this research proposal. The topic of the research has been prepared after through literature review of upto date research articles. The references of these articles have been provided in the reference section with the proposal. If there is any error that is purely unintentional, this may be corrected if it is pointed out. Also, it has not been submitted to elseware for the fulfillment of any other Degree and Diploma.

T. K. Sinha
(1805PHDTT04226)

Table of Contents

Sr. No.	Contents	Page No.
1	Self declaration	I
2	Plagiarism report	II
3	Table of contents	III
4	Introduction	1-2
5	Review of Literature	3 - 14
6	Rationale of Research	15
7	Objective of the Study	16
8	Proposed Methodology	17-18
9	Implications of the Proposed Research Work	19
10	Proposed Time line for PhD Work	20
11	References	21 - 26

1. Introduction

Properties of the yarn are very important in deciding the properties of the fabric. Out of the all properties of the yarn, yarn breaking extension is the least attended property as it is not having any direct effect. Still, it cannot be ignored, since it affects the performance of the subsequent processes in terms of productivity as well as quality of the product during winding, warping, sizing and weaving. The strength of the yarn has been always given utmost importance while neglecting the extensibility of the yarn which is also equally important in the subsequent processes. The breakage of any yarn during the process not only reduces the productivity but also introduces a defect in the fabric. A low strength yarn with higher extensibility is always desirable than a high strength yarn with lower extensibility. Simultaneously, yarn with higher strength and breaking extension with higher percentage of CV is also not desirable. Though the yarn strength is considered as an important property of the yarn, but in many cases it may not be the important one. Particularly in the field of technical textile like filtration fabric, packaging material, sports and swimming garments etc. where the extensibility is of the yarn or fabric is the prime factor. Considering above all, a yarn should have sufficiently high strength as well as extension with a CV as minimum as possible.

According to yarn breakage mechanism, a yarn can only break if there is a breakage of the fibre or there is a slippage of the fibre. Fibre strength and extension are responsible for breakage of the yarn. Also the amount of twist in the yarn is responsible for the breakage of the yarn as twist arrests slippage of the fibre. The fault in the machine parameters or in the process parameters may introduce many defects or the irregularities in the yarn. They also cause decrease in low yarn strength and extension. Theoretically, the breaking extension of yarn cannot be more than the fibre breaking extension. It has been always observed that the breaking extension of yarn is always less than the breaking extension of fibre [1].

So far, there is no adequate study to establish the relationship between the yarn and fibre breaking extension along with the other aspect like yarn twist, yarn count, structure of the yarn and yarn imperfections. In the following segment an effort is being made to project a current research status as the base of the proposed research work. In the proposed study, the investigation is intended to start with synthetic fibres like polyester, where the variation in the fibre properties are less or the matrix of fibre properties is homogeneous to a great extent. Later, artificial neural network based model will be formulated to predict the probable yarn

breaking extension and other yarn properties. In the following literature review segment, different contributors in yarn elongation are briefly discussed. Few of them are fibre characteristic such as fibre extension, fibre length and fineness, cross sectional shape of fibre along with processing parameters like twist in the yarn, yarn count, spindle speed, imperfections and blend ratios.

2. Review of Literature

Properties of yarn mainly depend on the properties of fibre. Out of all the yarn properties, yarn breaking extension is the least attended property. Yarn breaking extension is an important factor which decides the productivity and quality of product in the subsequent process like winding, warping, weaving and knitting. The yarn breaking extension basically depends upon the breaking extension of fibre and the resistance offered by the fibres against slippage. Yarn breaking extension is greatly influenced by the fibre breaking extension, the applied twist to prevent the slippage of fibre, yarn count, structure of yarn, imperfections and faults in the yarn, blend ratio, mixing and the other variables like fibre length, fineness, cross sectional shape, and frictional characteristic of fibre. A detailed literature review is carried out to get a thorough idea about the effects of those variables and their impact on yarn strength and elongation.

2.1 Fibre Extension and Testing Method

Fibre breaking extension depends upon the type of fibre, its length, fineness and method to measure the breaking extension. In this section, some of the papers related to fibre and yarn breaking extension has been included to understand their relationship. Also this segment is aimed to highlight the magnitude of fibre and yarn extension and their dependability on the testing methods.

Majumdar *et al.*[2] have stated that elongation of yarn is the least attended property and which cannot be ignored, since it affects the performance of the yarn during the subsequent processes. Yarn elongation is mainly influenced by the fibre properties, twist and yarn count. In this paper, three different models i.e., mathematical, statistical and artificial neural network based models had been used to estimate the power of prediction of breaking elongation of yarn and a comparison of their efficiency to conclude that artificial neural network method is best to predict the yarn properties. However they didn't investigated the effect of fibre extensibility.

Fibre and yarn breaking strength and extension are also depended on testing methods. Ghosh *et al.*[3] studied in this area. It has been found that the strength of spun yarn is affected by the two important parameters of the testing instrument i.e., the gauge length and the rate of extension. Their research had concluded about the decrease in the yarn strength as the gauge length was increased and improvement in yarn strength as a result of increased extension rate.

Conditioning of the yarn also improved the breaking extension. In this regard a work was done by Khan *et al.*[4] They have observed that after conditioning of the yarn, there was a remarkable increase in moisture content, elongation at break and decrease in the hairiness. Oxenham *et al.*[5] have identified fibre extensibility as the most important fibre parameter which affects the yarn tenacity of the air jet spun yarn. Benzina *et al.*[6] concluded in their study that the combination of increased fibre tenacity and decreased fibre elongation results in significant decrease in work of rupture of the yarn. At constant tenacity, with increased elongation, the work of rupture has shown significant improvement. Yang *et al.*[7] had pointed out a good correlation between Favimat single fibre elongation and tensor bundle elongation. However there was no correlation between Favimat single fibre elongation and HVI (High Volume Instrument) bundle elongation. Joshat *et al.*[8] have developed a yarn elongation prediction model on Kenyan ring spun cotton yarn based on Extreme Learning Machine (ELM). ELM model was found faster one in speed but Differential Evolution Extreme Learning Machine (DE-ELM) had predicted the value more accurately. However they have not studied the effects of fibre extensibility in that prediction. Tyagi *et al.*[9] have shown a positive correlation between elastic recovery and rate of extension of tensile tester while a negative correlation with amplitude of extension. Some useful data of fibre extension have been given in Table No.1 to understand the probable effect of fibre extension on yarn extension.

Sr. No.	Fibre Name	Fibre Breaking Extension (%)[10]	Expected Yarn Breaking Extension (%)[10]	Utilization (%) (calculated)
1	Cotton	6.8	5.0	75.5
2	Viscose	15.7	12.0	76.4
3	Nylon	26.0	18.0	69.2
4	Polyester	25.0	15.0	60.0
5	Acrylic	25.0	16.0	64.0

Table 1: Different fibre extension behavior[10].

2.2 Twist in the Yarn

The function of twist in staple yarn is to increase the resistance of fiber slippage under the influence of load to the yarn. Twist increases the cohesive force among the fibre and increases the inter fibre friction. Twist causes increase in transverse pressure which gives resistance to slippage and finally results in increased strength and elongation. Hence, as the twist in the yarn increases, both the strength and extension increases up to a certain extent and then decrease as the load sharing capacity of the fibre decreases due more non parallel alignment of the fibre (Fig. 1).[11]

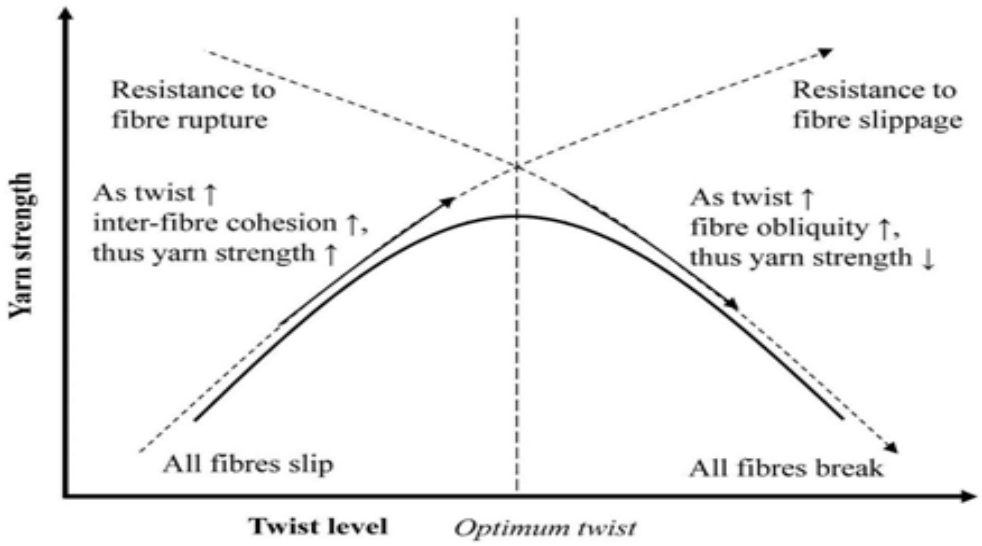
Resistance to fibre rupture
Resistance to fibre slippage
As twist ↑ inter-fibre cohesion ↑, thus yarn strength ↑
As twist ↑ fibre obliquity ↑, thus yarn strength ↓
Yarn strength
All fibres slip
All fibres break
Twist level
Optimum twist

Figure 1. Effect of twist on fiber slippage[11].

Initially the strength of parallel fibre assembly increases with the increase of transverse pressure. Chaudhuri *et al.*[12] had studied this phenomena and found the effects of surface fibres which provide the transverse force on the tenacity of the yarn. A regression equation was also developed between the percentage surface fibre (0 to 40%) and applied transverse force (0 to 100 g/cm^2) to predict the tenacity of the yarn (4.5 to 22.8 cN/tex). Mertova *et al.*[13] have reported about the increase in the breaking elongation of multifilament yarn 24.7 % to 40 % with the increase in twist factor from 0 to 229.5. Agarwal *et al.*[14] had carried out an experiment by varying count (18, 36, 72) on different twist multiplier (2.75 to 5.75) and developed a mathematical model to predict the yarn breaking elongation with accuracy level of -3.2 to +5.2%. Yin *et al.*[15] have developed a theoretical model of flexible yarn dynamics on a moving rigid cylinder as twisting element. It was found that twist angle and yarn tension had

some influence on the twisting process. Also, torsional rigidity of yarn had varied with the system parameters such as twist levels, tension levels, and speed ratio and wrap angle. Hussain *et al.*[16] have shown the improved packing density from 0.22 to 0.32 with the increased twist from 9.7 to 24.1. They also reported that increase in hairiness, increase the diameter and reduce the packing density. Increased twist improved the packing of fibre and reduced the chance of fibre slippage which had helped to get the yarn extension equal to fibre extension.

2.3 Physical Properties of Fibre

The physical properties of fibre are basically length of fibre, fibre fineness i.e. diameter and cross sectional shape. Staple length of fiber is that length between two lines of a tufted fibrous mass where the density of fibers changes abruptly. It is mostly used in case of natural fibers where the length variation of fibers is more[17]. A longer fibre twists the yarn more effectively rather than a short fibre. It reduces the discontinuity in the yarn and has more specific surface area. The fineness of the fibers may be defined as the mass per unit length. The various cross sectional shape of fibre affects the torsional rigidity, packing density and resistance to slippage. Fine fibre in a given yarn count means more number of fibre and more specific surface area. Therefore more resistance to slippage is gained. Hence a longer, finer fibre expected to provide better yarn strength and elongation. Irregular cross sectional shape of fibre also increase resistance to slippage as compare to circular cross sectional fibre. Varshney *et al.*[18] have reported the effects of fineness and cross section of fibre in the yarn hairiness and also in the mechanical properties of yarn. Higher denier fibres have resulted higher hairiness. Also, Young's modulus of the yarn has increased from 443.6 cN/tex to 546.6 cN/tex with linear density of fibre from 0.99 dtex to 2.22 dtex and also with twist factor from 27.26 to 33. But bending stiffness gets reduced with twist and increased with linear density of fibre. It has been reported that yarn spun from trilobal fibre shows higher modulus and flexural rigidity than circular fibre[18]. Since the fibre fineness, specific surface area, cross sectional shape and twist affect the fibre slippage phenomena, the tensile properties of yarn will also be affected. Scalloped oval fibre produces yarn of lower rigidity than circular and tetrakelion fibre. Fibre length is an important parameter in deciding the yarn strength and extension. In this area Parsi *et al.*[19] have shown that increase in the fibre length from 29.7 mm to 31.4 mm, has caused increase in RKM value from 17.2 km to 17.6 km in single yarn strength. Longer fibre shows less hairiness in the yarn. The fineness of fibre, cross sectional shape, number of fibres etc.

has some definite effect on the mechanical properties of the yarn[20]. Hager *et al.*[20] concluded that fibre length, fibre strength and short fibre content are the most important contributors in the hairiness index for combed cotton ring yarn. On the other hand, fineness of fibre and short fibre content are important for compact spun yarn. Longer and finer fibres have more specific surface area which improved the yarn strength and elongation. Shorter and coarser fibre produces more hairs in the yarn and become stiffer. Figure 2 shows the cross sectional shape of different types of fibres[21].

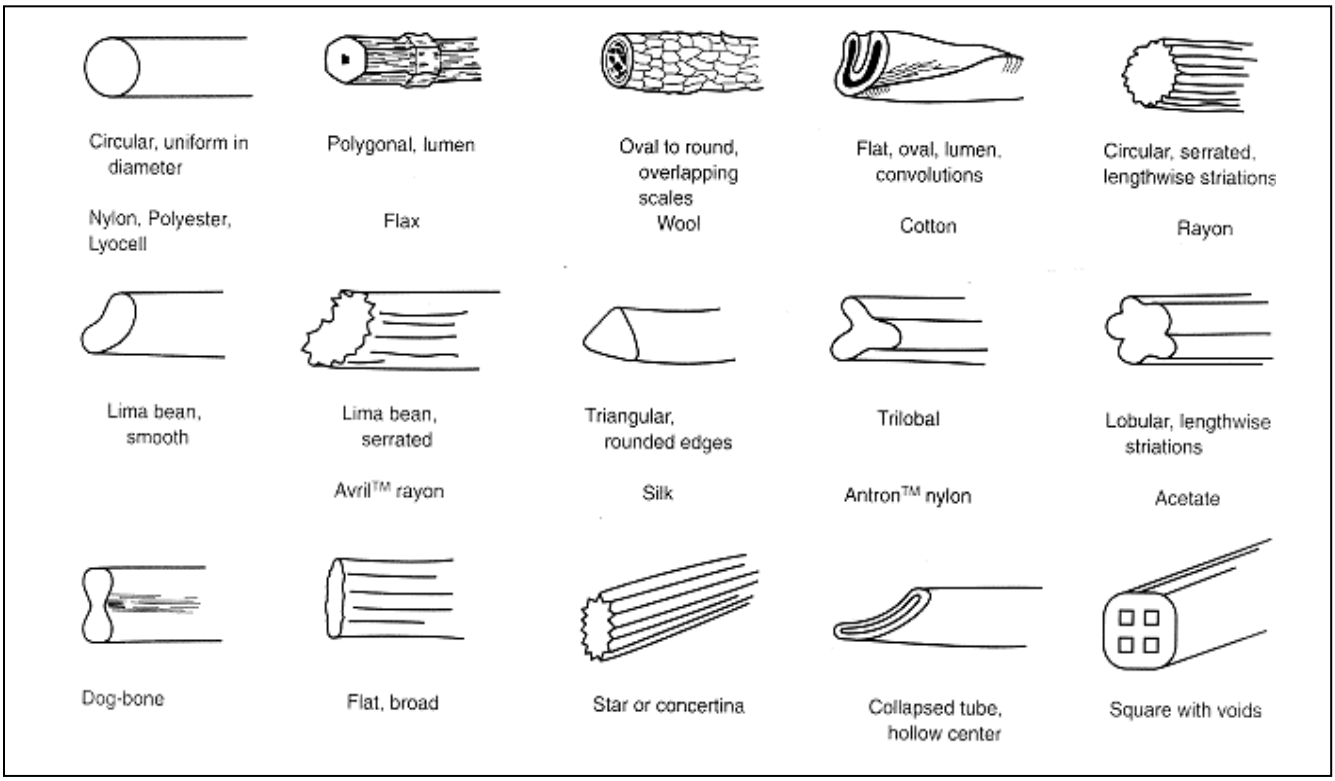

Figure 2. Cross section of some textile fibres[21].

Basu *et al.*[22] stated that finer fibre improves the flextural rigidity and compressional energy of polyester spun airjet yarn whereas increase in fibre length reduces the hairiness and yarn to metal friction. Reduction in metal to yarn friction will generate less hairiness in the yarn which is expected to have better strength and extension in the yarn. Tyagi *et al.*[23] have observed that open end yarn made from circular cross section polyester staple fibre had better tenacity, breaking extension, work of rupture and hairiness as compared to trilobal polyester fibre. Chatterjee *et al.*[24] had found that wicking behavior of polyester fabric both warp and weft way was greater than theoretical calculation based on Lucas-Washburn equation. Their

study threw some light on the physical properties of polyester fibre on its higher moisture retention capability in spite of having low moisture regain. Ramkumar *et al.*[25] reported that the friction of friction spun yarn is influenced by the various factors like type of fibre and the applied tensions.

2.4 Imperfections and Process Variables

The aim of this segment is to show the effect of yarn imperfections, faults and process variables to the corresponding properties of yarn. Sometimes wrong setting of machine and process parameters introduce various faults and imperfections to the yarn. In that case, reasonably strong yarn may exhibit a low strength and extension. Imperfections like thick places, thin places and neps are important. Long thick and thin places generate faults in the yarn which cause variation in yarn strength and elongation. The yarn breaking extension also gets affected by those induced imperfections. Among the various process variables, setting in the drafting zone, quality of cots and aprons, break draft, total draft, delivery speeds are crucial for the generations of imperfections. The quality and condition of the cots and apron have a great influence on the generation of imperfection. The hardness of the cots and aprons, buffing conditions, wear and tear out conditions play a major role in this.[58]

Increased imperfections are the one of the main reasons of low yarn strength and elongation. Mamum *et al.*[26] have compared the properties of carded ring and compact yarn. They have found less count CV, total imperfections, hairiness with better yarn strength and elongation for compact yarn. Ramachandran *et al.*[27] have shown reduction of yarn hairiness to a large extent by gas singeing. The overall imperfections like thick places and neps have reduced substantially. Ochola *et al.*[28] have pointed out the factors which have most influence on the total imperfections in the yarn. They are twist, micronaire value, maturity, trash area, length, strength and yellowness of fibre.

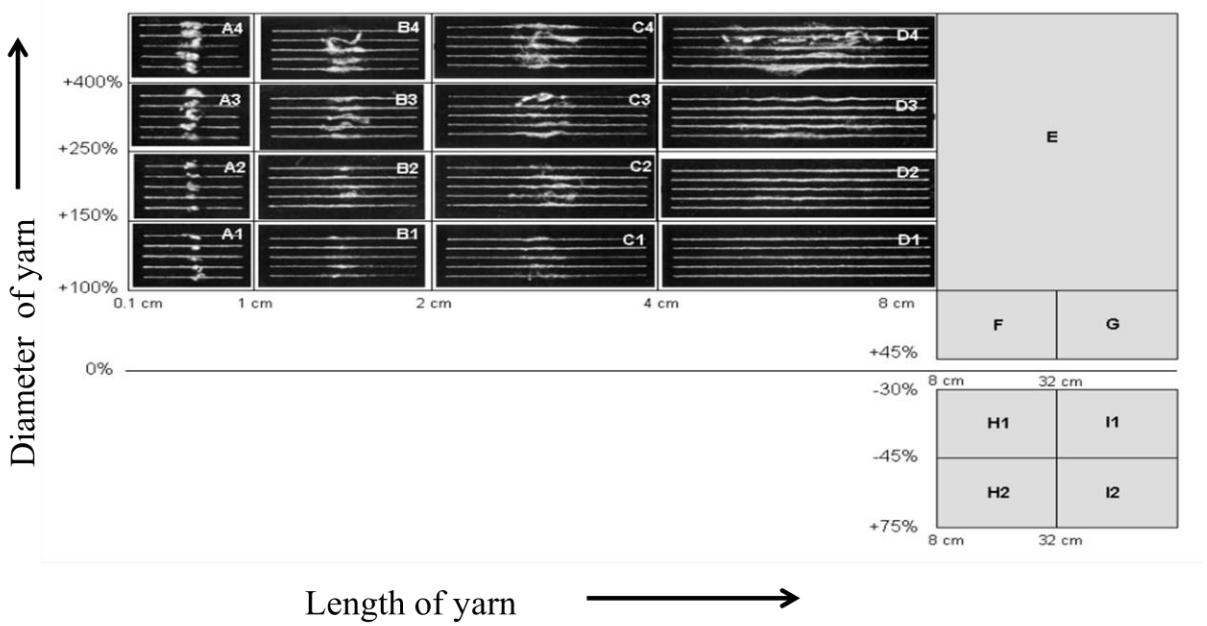

Figure 3. Classimate faults[29].

Khalid *et al.*[30] reported through an experimental study that Support Vector Mechanism model has predicted the yarn properties much better than Artificial Neural Network model. Furferi *et al.*[31] also used ANN method to predict the yarn strength from the common properties of fibre and claimed that the results can be obtained within a second.

Eldeeb *e tal.*[32] found improved yarn hairiness for air jet spun yarn when ply twist was given in the same direction of single yarn twist. Opposite direction twist had increased the tenacity of the yarn and reduced snarling tendency. Faulkner *et al.*[33] have stated fibre length and yarn strength as major controller for yarn evenness variation. Other than those, it is also influenced by variation in fibre length, fibre fineness and reflectance value which is dependent of maturity of fibre.

Price *et al.*[34] used partial least square regression technique and concluded that High Volume Instrument (HVI) data are important for bale management to predict the yarn quality, whereas Advance Fiber Information System (AFIS) data allow textile mills to monitor and maintain the process quality. Chattopadhyay *et al.*[35] explored the possibility of improvement of the performance of neural network by cutting down the number of inputs in the network based on the strength of correlation coefficients.

Patnaik *et al.*[36] reported the nozzle winding technique in winding to reduce the hairiness in ring, rotor, air jet and Dref-II yarns. S3 value of all nozzle spun yarns were 16 to 30% less than that of their counterpart yarns. Long hairs were very less in ring and air jet yarn but more

in rotor and Dref-II yarns. Liu *et al.*[37] reported that the hairiness in the yarn can be reduced by right and left off setting a device in the spinning zone. The various settings in the drafting zone affect the properties of the yarn which affects the strength and extensibility of yarn. Karthik *et al.*[38] used cotton and milkweed blended yarn in their study. The objectives of this study were to find out the effects of fibre friction with respect to fibre and machine components like roller setting and top roller pressure on the properties of the yarn. Their research was inconclusive but all the yarn characteristics had shown an increasing trend with the observed value with the increase in fibre friction value. Merati *et al.*[39] developed a special diagonally slotted roller to control the edge fibre and concluded that the spinning technique has improved the hairiness and mechanical properties of the ring spun yarn even more successfully than solo spinning system. Zou *et al.*[40] had studied the effects of process variables on viscose vortex coloured yarn and found that nozzle pressure and yarn delivery rate have significant effect on yarn properties. He had concluded about initial increase in Yarn tenacity from 7.7 to 10.5 cN/tex with subsequent decrease from 10.5 to 7.27 cN/tex with respect to nozzle pressure from 0.45 to 0.55 MPa and yarn delivery rate from 320 to 380 mpm. They had also observed decrease in yarn diameter from 223.2 to 190.7 μm and improved evenness from 17.02 to 12.65% with the nozzle pressure from 0.45 to 0.55 MPa. However, continuous increase in nozzle pressure has caused detrimental effect on yarn tenacity with initial improvement in the same. Tyagi *et al.*[41]stated that the fabrics made from compact yarn were less extensible and possessed higher shear and bending rigidity. Twist factor and spindle speed marginally affected the fabric extensibility. In another study Tyagi *et al.*[42] concluded that in air jet spinning the process variables like feed ratio, main draft, nozzle pressure and spinning speed had significant influence on flexural rigidity of yarn. It increased from 7.3 to 8.6 $g.cm^2 \times 10^3$ with feed-ratio 0.96 to 0.99, main draft from 30 to 40 and nozzle pressure from 2 to 3.5 kg/cm^2. Similarly, elastic recovery had shown increasing trend with increasing overfeed and main draft. But it showed decreasing trend with the increase of nozzle pressure. Ishtiaque *et al.*[43] reported an increase in strength and breaking elongation of yarn, whereas decrease in the U%, total imperfections, hairiness and long thin faults in the yarn with the increased delivery speed of draw frame and coiler diameter of card. In general, increase in card draft leads to the deterioration of yarn quality i.e. reduction of yarn tenacity and breaking elongation of yarn and increase in yarn hairiness, U%, total imperfections. Tyagi *et* al.[44] reported that an increase in add on finish, first nozzle air pressure and main draft in airjet

spinning of polyester staple yarn have shown an increasing trend in elastic recovery whereas it get reduced with higher spinning speed.

2.5 Structure of Yarn

There are various types of yarn like ring, rotor, air-jet, Dref etc. (Fig 4). Each technology manufactures such yarns, which are different from each other. The structures of these yarns are different and cause difference in strength and extension. Basu *et al.*[45] reviewed the changes in the yarn structure with the yarn production technology. The process used for manufacturing such yarns and also the fiber parameters contributes largely to the properties of yarns. He also stated that yarn structure is mainly dependent upon the technology through which the yarn is manufactured.

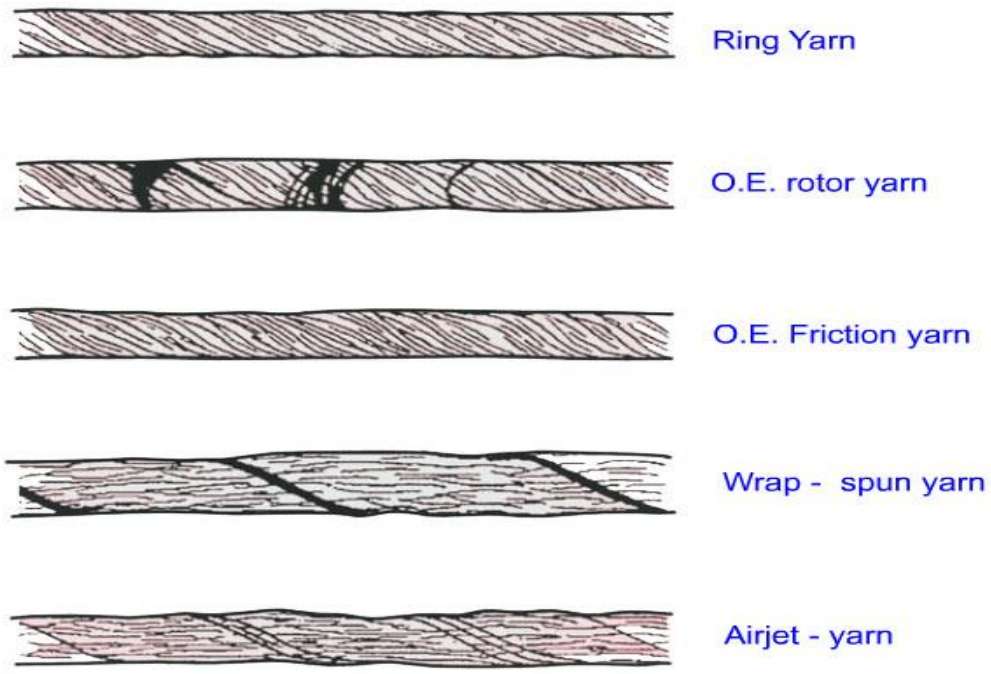

Figure 4. Structures of yarns produced with different technology (O.E.: Open-End)[46].

Bharani *et al.*[47] studied the tensile behavior of ring, rotor, airjet and Dref-3 yarns. They found that increase in gauge length of the tensile testing instrument had decreased the yarn tenacity and breaking extension. But it increased the time to break, work of rupture and young's modulus of yarn. In case of air jet yarn, the drop in tenacity was highest and for rotor yarn it was minimum. Ring yarn had shown highest modulus followed by rotor and air jet. Modulus was highest in finer yarns as compared to their coarser counter parts. Nassif *et* al.[48] studied

compact spinning technique in which the hairiness of the yarn was reduced substantially and the physical properties of yarn was improved as compare to ring spinning system. Hasan *et al.*[49] studied the Lycra integrated slub yarn. It showed lower unevenness, imperfection and strength values than that of normal slub yarn. The insertion of Lycra in the core of normal slub yarn had increased elongation percentage of yarn from 3.34 to 4.16%. They had found that increase in the Lycra percentage in the yarn has reduced the hairiness than the normal slub yarn. Gopalakrishnan *et al.*[50] studied the modified rotor yarn by pre-compressing the sliver and found that there was an improvement in the yarn strength from 9.51 to 10.25 g/tex and elongation from 5.68 to 6.14% with reduced total imperfections from 313 to 146. Ahmed *et al.*[51] reported that due to difference in structure of ring, rotor and air jet yarn, the properties of these yarns were changed. They concluded that rotor spinning system could produce the best quality yarn by incorporation of stronger fiber with high twist.

Su *et al.*[52] studied the structure of compact-siro yarn and concluded that the yarn was having more compact and clear surface structure, more uniform, smoother shape and less hairiness as compare to single compact yarn. Compact-siro spun yarn has near circular cross section which improves the yarn quality. Ishtiaque *et al.*[53] carried out a study on the structure of siro spun yarn and concluded that the packing density of fibre over the yarn cross section was not uniform and maximum packing density occurs at approximately 1/3 rd of yarn radius from the yarn axis. The strength of siro yarn was greater than ring yarn as the packing density of siro yarn was higher than ring yarn.

Ishtique *et al.*[54] found that the yarn diameter of both ring and rotor yarn get reduced with the increase in yarn extension and the mean fibre extent of both the yarn get increased. The observed effect was more pronounced in rotor yarn as compare to ring yarn. Tyagi *et al.*[55] stated that yarn structure has prominent effect on fabric comfort properties. They found that fabric made from compact spun yarn has lower thermal resistance, higher water and air permeability as compare to ring spun yarn fabric. Air and water permeability of compact spun yarn fabric had shown directly proportional relationship with twist factor and spindle speed. Tyagi *et al.*[56] found that annealing treatment to Dref-3 polyester yarn had improved the breaking extension, work of rupture, helix angle and helix diameter but there was decrease in yarn tenacity and hairiness. Mahish *et al.*[57] observed that thermal treatment in wet condition had improved the breaking extension, linear density and helix angle whereas tenacity of yarn get reduced.

2.6 Blend Ratio and Mixing

The composition of fibre and fibre type affect the yarn strength and elongation behavior. Blended yarn with different types of fibre will give variation in yarn extension. Moreover, percentage of fibre component also plays an important role in deciding the yarn extension. In case of cotton, the mixing may consists cotton fibres of various grades and breeds with variation in staple length, micronaire value, maturity and trash content. Those also affect the yarn properties including breaking extension. Other than cotton, polyester is the largest synthetic fibre in use in textile. Usually it is blended with other synthetic fibre like viscose or natural fibre like cotton as per the requirement.

Moghassem *et al.*[58] studied the polyester cotton blended yarn with different blend ratio and concluded that all rotor spun yarn had higher elongation at break as compare to ring yarn. Elongation at break of both ring and rotor spun yarn were increased from 16.9% to 88.3% as the percentage of polyester fibre had increased from 16.5% to 83.5% in the blend. Shahid *et al.*[59] have carried out an experimental study for jute blended yarn with polyester, wool and acrylic and found that the overall properties of the blended yarns were better than 100% jute yarn. Best quality yarn was achieved with jute and polyester blended yarn of 80/20%. Choudhury *et al.*[60] had carried out a study on yarn of eri silk and acrylic blend. They found that tenacity of the blended yarn had reduced from 15.7 to 6.25 cN/tex with the increase in the proportion of eri silk from 33 to 67%. Tenacity had also reduced with the fineness of yarn. Ramasamy *et al.*[61] reported about 100 % cotton yarn which had highest hairiness. They have shown the reduction of hairiness with the increase in percentage of Tencel fibre. Hairiness was minimum in case of yarn with 100 % Tencel fibre. Baykal *et al.*[62] conducted a study and found the proposed regression model as highly efficient in predicting the strength and elongation properties of rotor yarns.

Tyagi *et al.*[63] studied the polyester/viscose and polyester/cotton yarn in ring and air jet spinning. In their study they found that air jet yarn had shown better structural integrity, lower compressional energy, higher resiliency, lower abrasion resistance and less hairiness with respect to ring spun yarns. They concluded that Murata Jet Spun (MJS) polyester/cotton blended yarns were more hairy than polyester/viscose blended yarn. They also mentioned about less hairiness of yarn made with trilobal fibre than the yarn made with circular fibre.

2.7 Introduction to Artificial Neural Network[64 - 74]

In recent years, neural networks have been used as a technology for modeling an efficient industrial process. An improvement in their performance may be expected either by divining more efficient training algorithms or by intelligently working on the data set.

ANN is suitable for modeling nonlinear relationship. It is a suitable data modeling tool that is able to capture and represent any kind of input –output relationships. The theory of ANN and application in textile engineering process and modeling yarn properties studies are extensively discussed in many reviews in last few years.

Yarn strength is one of the most significant parameters to be controlled during yarn spinning process. This parameter strongly depends on both the rovings' characteristics and the spinning process. On the basis of their expertise textile technicians are able to provide a raw and qualitative prediction of the yarn strength by knowing a series of fiber parameters like length, strength, and fineness.

Artificial Neural Network-based model will be able to help the technicians in predicting the yarn strength on the basis of various efficient parameters.

Artificial Neural Network-based model will include following major steps

(i) Database creation,

(ii) Definition of training parameters,

(iii) Artificial Neural Network construction and training.

3. Rationale of Research

Fibre breaking elongation is an important property of fibre which contributes to the yarn extension. Yarn extension is responsible for the performance of various post spinning operations and also in its application particularly in technical textile. Both the productivity and quality of product of the various processes are affected by the yarn breaking extension. Practically yarn breaking extension cannot be more than the breaking extension of fibre. Most often it is found that the breaking elongation of yarn is far below than the breaking extension of fibre. Hence, the importance of fibre extension behavior cannot be neglected.

From the literature review, it is evident that very few works has been commenced to deduce the relationship of fiber and yarn extension behavior. Also there is no concentrate mathematical model to predict yarn extension with the help of fiber extension. Since this area is not explored, there is a scope of work on the impact analysis of the relationship between the breaking extension of fibre and the breaking extension of yarn under some preset important machine and process parameters. The present study is aimed at a systematic methodical approach to find out the impact of fibre breaking extension to the yarn breaking extension. It will be preferred to establish an artificial neural network based modeling solutions to predict the expected yarn breaking extension from the data of known fibre breaking extension for 100 % polyester fibre under three/four level of twist level and yarn count keeping all other variable constant. Polyester is the largest used fibre after cotton. Though there are some few work on the 100% cotton fibre but there is no such work on polyester. This research work will draw some light on the contribution of polyester fibre extensibility to the total extensibility of 100% polyester yarn and use of artificial neural network to predict the yarn breaking extensibility will be unique in its nature. It will save huge wastages of material due to destructive characterization of test even before the yarn is made.

4. Objective of the Study

From the literature review, it is well understood that out of all the properties of yarn, the yarn breaking extension is the least attended property though is very useful in practical field. The strength of yarn alone is not sufficient to judge the performance of yarn in the subsequent processes. Extensibility plays a very important role in the assessment of the yarn. Moreover, yarn breaking extension is influenced by many factors out of which some factors are having major role to play.

The objective of the proposed research work is to find out the relationship between the breaking extension of fibre to the breaking extension of ring spun yarn under certain pre-set important machine and process parameters and to propose an artificial neural networking based impact analysis model to predict the expected breaking extension of yarn from the known fibre breaking extension. The aforesaid objectives can be further sub divided into the following goals.

1. Identification of present machine and process parameters for the study to produce 100% polyester yarn and factors which influence the yarn breaking extension and other properties of yarn.

2. Collection of data in terms of yarn and fiber extension and also other properties of fibre and yarn at preset machine and process parameters.

3. Identification of various development of appropriate artificial neural network model for 100% polyester yarn to predict the yarn breaking extension and other properties.

4. Testing of the prediction power of the model with real data.

\

5. Proposed Methodology

5.1 The Study

The present research work will focus on the fibre breaking extension and their contribution to the yarn breaking extension under some preset important process and machine parameters like length of fibre, twist multiplier, count keeping all other parameter constants. This study will have an emphasis to do the impact analysis of the relationships between the breaking extension of fibre to the yarn under at least three different level of twist multiplier and yarn count in ring spinning system. It will also include an artificial neural networking based predictive model which can be effectively utilised to design the yarn with expected breaking extension as per our requirement.

5.2 The Sample

The sample yarns will be made in ring spinning system at an industry or at lab keeping all machine and process parameters same except the yarn count and twist multiplier.

5.2.1 Proposed Material

100 % polyester yarn of different count and twist multiplier will be made as sample. Fibre length, fineness and spin finish level will be kept constant.

5.2.2 Proposed Mechanism

More than 90% yarns are manufactured in ring spinning technique. Hence, ring spinning technique will be used to manufacture yarn so that the structure of all the sample yarn will be same. All the machine parameters will also be kept constant. The variables will be as follows:

Table 2. Proposed variability level on the Research.

Type of materials (100 %)	Polyester
Level of twist	4 level
Yarn count	5 count
Fibre extension	3 level

More variable can be used depending upon scope and time.

5.3 The Tools for Data Collection

The yarn will be manufactured at the lab or industry. The testing of fibre and yarn will be carried out in the lab or in the industry. A detailed testing of yarns will be carried out particularly the breaking extension, strength and imperfections properties. The yarn will be tested in auto sorter for count, tensile strength tester for breaking strength and elongation, and in uster tester for yarn imperfections and hairiness.

5.4 Data Analysis

Investigation can be done using Design of Experiment, model like Taguchi which will facilitate to drastic reduction in number of samples. It will also help to see the effect of main factors and the interactive effect of two or more factors and their contribution towards the response in terms of yarn extension. However other responses like tenacity, initial modulus and work of rupture, hairiness, and imperfections are of importance which may also be found out. The Regression analysis can also be done to see the effect of factors and their importance. Regression model can be developed. In this study, development a prediction model based on artificial neural network to predict the expected results will be approcached. The efficiency of the model will also be judged with the actual results.

6. Implications of the Proposed Research Work

It is expected that the proposed research work will add some new concept to the contribution of fibre breaking extension to yarn breaking extension. A critical study on this may open up the possibility to get optimum yarn breaking extension. It will help to design a yarn for a specific purpose especially for technical textile with maximum utilization of fibre extension. Further, the proposed model will be helpful in predicting the expected value of yarn breaking extension and other properties before the yarn is manufactured and will save huge wastages of material due to destructive characterization of test.

7. Proposed Time line for PhD Work

Time in Month (1 QTR = 3 months) →	3	6	9	12	15	18	21	24	27	30	33	36
Activities ↓												
Literature Review & Gap Analysis												
Sample Preparation and Testing												
Data analysis and Interpretation												
Conclusions												
Paper Writing												
Thesis writing												

8. References

1. Pan, N.; Hua, T.; Qiu, Y. (2001). Relationship between fiber and yarn strength, Textile Research Journal, 71, 960-964.
2. Majumdar, P. K. (2004). Predicting the breaking elongation of ring spun cotton yarn using mathematical, statistical, and artificial neural network models. Textile Research Journal, *74*, 652 – 655.
3. Ghosh, A.; Ishtiaque, S.M.; Rengasamy, R. S. (2004). Spun yarn strength as a function of gauge length and extension rate: a critical review. Journal of Textile and Apparel Technology and Management, *4*(2), 1 – 13.
4. Khan, A. N.; Nafis A.; Hawladar, M. R. (2017). Comparison of several cotton yarn properties before and after conditioning. International Journal of Textile Science, *6* (3), 88 – 91.
5. Oxenham, W. (1992). Influence of fibre properties in air jet spinning. Indian Journal of Fibre and Textile Research. *17*, 194 – 200.
6. Benzina, H.; Hequet, E.; Abidi, N.; Gannaway, J.; Drean, Y. J.; Hazzallah, O. (2007). Using fibre elongation to improve genetic screening in cotton breeding programme. Textile Research Journal, *77*(10), 770 – 778).
7. Yang, S.; Gorden, S. (2016). A study on cotton fibre elongation measurement. 33rd International Cotton Conference Bremen, March 16-18, 2016, 1 – 16.
8. Josphat, I. M. (2017). The prediction of yarn elongation of Kenya ring spun yarn using extreme learning machine. Tekstilec, Turkey, 60(1), 65 – 72.
9. Tyagi, G. K.; Goyal, A.; Patnaik, A. (2002). Elastic recovery properties of polyester jet spun yarn. Indian Journal of Fibre and Textile Research, *27*, 352 – 357.
10. Morton, W. E.; Hearle, J. W. S. (2008). Physical properties of textile fibre, 4th edition, Woodhead Publication Limited.
11. Shah, D. U.; Schubel, P. J.; Clifford, M. J. (2012) Modelling the effect of yarn twist on the tensile strength of unidirectional plant fibre yarn composites. Journal of Composite Materials, *47*(4), 425-436.
12. Chaudhuri, A.; Majumdar, P. K. (2014). Effects of transverse pressure on tensile properties of parallel fibre assembly. Indian journal of Fibre and Textile Research, *39*, 43 – 48.

13. Mertova, I.; Mouckova, E.; Neckar, B.; Vysansha, M. (2018). Influence of twist on selected properties of multifilament yarn. Autex Research Journal. *18*(2), 110 – 120.
14. Agarwal, S. K. (1989). A model to estimate the breaking elongation of high twist ring spun cotton yarn. Textile Research Journal, *59*, 691 – 695.
15. Yin, R.; Tao, X. M.; Xu, B. G. (2016). Mathematical modeling of yarn dynamics in a generalized twisting system. Scientific Reports, DOI:10.1038/srep24432. 1 – 13.
16. Hussain, U.; Surwar, A.; Shafqat, A.R,; Iqbal, M., M.; Zahra, N.; Ahmed, F.; Hussain, T. (2014). Effect of spinning variables on packing density of cotton yarn. Indian Journal of Fibre and Textile Research, *39*, 434 – 436.
17. Booth, J. E. (1963) Principles of Textile Testing, 3rd Edition. Qutterworth Scientific, London.
18. Varshney, R.; Kothari, V. K.; Dhamija, S. (2014). Influence of polyester fibre shape and size on hairiness and some mechanical properties of yarn. Indian Journal of Fibre and Textile Research, *39*, 24 – 32.
19. Parsi, R. D.; Kakde, V. M.; Pawa, K.; Patil, P. R.S. (2016). Influence of fibre length on ring spun yarn quality. International Journal of research and scientific innovation, *3*(8), 154 – 156.
20. Hager, M. A.; Hassan, A. A. (2016). Use of correlation and regression analysis in estimating relative importance of fibre properties affecting the yarn hairiness in some egypian cotton. International Journal of Advanced Research, *4*(8), 1274 – 1284.
21. Cross secton of fibre.https://www.google.com/search?q=cross+section+fibre &source =lnms&tbm=isch&sa=X&ved=0ahUKEwju4cQuKniAhVMqY8KHVadCKoQ_AUI DigB&biw=1440&bih=789#imgrc=GEofCTQdVaBn_M: (Accessed on 06 May 2019).
22. Basu, A.: Chellamani, K. P. (2000). Influence of fibre length and denier on properties of polyester ring and airjet spun yarns. Indian Journal of Fibre and Textile Research, *25*, 163 – 169.
23. Tyagi, G. K. (2003). Effect of fibre profile, spin finish and opening roller speed on properties of polyester OE rotor spun yarns. Indian Journal of Fibre and Textile Research, *28*, 411 – 417.
24. Chatterjee, A. : Singh, P. (2014). Studies on Wicking Behaviour of Polyester Fabric. Journal of Textiles, Article ID 379731, ,http://dx.doi.org/10.1155/2014/379731.

25. Ramkumar, S. S.; Shastri, L.; Tock, R. W.; Smith, M. L..; Padmanabhan, S. (2003). Experimental study of the frictional properties of friction spun yarn. Journal of Applied Polymer Science. *88*, 2450 – 2454.
26. Mamun, R. A.; Repon, M. R; Jallil, M A,; Uddin, A. J. (2017) Comparative study on card yarn properties produced from conventional ring and compact spinning. Universal Journal of Engineering Science. *5*(1). 5 – 10.
27. Ramachandran,T.; Thirunarayanan, A. (2015). Influence of gas yarn singeing on viscose spun yarn characteristic. Journal of Polymer and Textile Engineering. *2*, 34 – 38.
28. Ochola, J.; Kissato, J.; Kinathia, L.; Muasiagi, J.; Waithaka, A. (2012). Study on the influence of fibre properties on yarn imperfection in ring spun yarn. Asian Journal of Textile. *2*(3), 32 – 43.
29. Kretzschmar, S. D.; Furter, R. (2008) The yarn classification system, Uster Manual,1-16.
30. Khalid, A. A. A.; Yu, C. (2013). The performance of data mining technique in prediction of yarn quality. International journal of Innovation Management and Technology. *4*, 390 – 392.
31. Furferi, R; Gelli, M. (2010). Yarn strength prediction: a practical model based on artificial neural networks. Advances in Mechanical Engineering., Doi: 10.1155/2010/640103.
32. Eldeeb, M.; Mouckova, E.; Ursiny, P. (2017). Properties of viscose air jet spun plied yarn. Indian Journal of Fibre and Textile Research, *42*, 386 – 390.
33. Faulkner, W.B; Hequet, E. F.; Wanjura, J; Boman, R. (2012). Relationships of cotton fibre properties to ring spun yarn quality on selected high plains cotton. Textile Research Journal, *82*, 400 – 414.
34. Price C.; Senter, H.; Foulk, J; Gamble, G.; Meredith, W. (2009). Relationship of fibre properties to vortex yarn quality via partial least squares. Journal of Engineered Fibres and Fabrics, *4*, 37 – 46.
35. Chattopadhyay, R.; Guha, A; Jayadeva (2004). Performance of neural networks for predicting yarn properties using principal component analysis. Journal of Applied Polymer Science, *91*, 1746 – 1751.

36. Patnaik, A.; Rengasamy, R.S.; Ishtiaque, S. M.; Ghosh, A. (2007). Hairiness of spun yarns and their reduction using air nozzle in winding. The Journal of The Textile Institute, *98*, 243 – 249.
37. Liu X.; Su X. (2016).Yarn hairiness on ring spinning with modified yarn path. Indian Journal of Fibre and Textile Research, *41*, 221 – 225.
38. Karthik, T.; Murugan, R. (2016). Optimization of drafting zone variables in the ring spinning for the production of cotton/milkweed blended yarn. Indian journal of Fibre and Textile Research, *41*, 121 – 128.
39. Merati, A. A.; Yazdi, A. A., ; Aliasghar, A. (2014). Yarn properties developments with diagonally slotted roller on ring spinning machine. Indian Journal of Fibre and Textile Research, *39*, 289 – 295.
40. Zou, Z. (2004). Effect of process variables on properties of viscose vortex coloured spun yarn. Indian Journal of Fibre and Textile Research, *39*, 296 – 302.
41. Tyagi, G. K.; Bhattacharya, D.; Bhowmicck, M.; Narang, R. (2010). Study of cotton ring and compact spun yarn fabric: part –i, effects of spinning variables on hand related characteristics . Indian Journal of Fibre and Textile Research, *35*, 45 – 49.
42. Tyagi, G. K.; Kaushik, R.C.D.; Salhotra, K. R.(1995).Influence of process parameters on flexural rigidity and elastic recovery of mjs yarn. Indian Journal of Fibre and Textile Research, *20*, 214 – 217.
43. Ishtiaque, S. M.; Mukhopadhyay, A.; Kumar, A. (2008). Influence of draw frame speed and its preparatory processes on ring yarn properties. The Journal of Textile Institute, *99*, 533 – 538.
44. Tyagi, G. K.: Singh, A.: Goyal, A. (2004). Effect of add on finish and process variables on recovery properties of jet spun polyester yarn. Indian Journal of Fibre and Textile Research, *29*, 44 – 48.
45. Basu, A. (2009). Yarn structure properties relationship. Indian Journal of Fibre and Textile Research, *34*, 287 – 294.
46. Alagirusamy, A.(2014) Yarn manufacturing-II,NPTEL lecture series, (https://www.google.com/search?q=Structures+of+yarns&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjFm8yAiaLiAhXFR30KHRWeD2EQ_AUIDigB&biw=1440&bih=740#imgrc=N8v0YPfZfExJPM:) IIT Delhi (Accessed on 10 May 2019).

47. Bharani, M.; Gowda R.V. M. (2012). A study of tensile behavior of ring, rotor, airjet and dref-3 friction yarns at different gauge length. International journal of scientific and Research publications, 2, 1 – 11.
48. Nassif, G. A. A. (2014). A comparative study between physical properties of compact and ring yarn fabrics produced from medium and coarser count of yarn. Journal of Textiles, *14*, 1 – 6.
49. Hasan, M. A. (2017). A comparative study between lycra integrated slub (lis) yarn and normal slub yarn produced in same ring spinning frame. International Journal of Scientific & Engineering Research. *8*, 1452 – 1460.
50. Gopalakrishnen, K. (2018). A study on properties of modified rotor spun yarn. International Journal of Trend in Scientific Research and Development. *2*, 653 – 658.
51. Ahmed, S.; Syduzzaman M.; Mahmud, M. S.; Ashique, S. M. (2015). Comparative study on ring, rotor and air jet spun yarn. European Scientific Journal. *3*, 411 – 424.
52. Su, X; Gao, W; Liu, X; Xie, C; Xu, B. (2015). Research on compact siro spun yarn structure. Fibres and Textiles in Eastern Europe. *23*, 54 – 57.
53. Ishtiaque, S. M.; Sharma, I. C.; Sharma, S.(1993).Structural mechanics of siro yarn by microtomy. Indian Journal of Fibre and Textile Research, *18*, 116 - 119
54. Ishtique, S. M.; Das, A.; Mallik, P. K. (2011). Structural changes in yarn during extension and their relationship with subsequent processes. Indian Journal of fibre and Textile Research, *36*, 221 – 226.
55. Tyagi, G. K.; Bhattacharyya, D.; Bhowmick, M.; Narang, R. (2010). Study of cotton ring and compact spun yarn fabric: part –ii, effects of spinning variables on comfort characteristics. Indian Journal of Fibre and Textile Research, *35*, 128 – 133.
56. Tyagi, G. K.; Raj, K.: Singh, J. (2007). Structural and Mechanical Characteristics of polyester Dref-3 yarns in relation to fibre profile and annealing treatment. Indian Journal of Fibre and Textile Research, *32*, 27 – 32.
57. Mahish, S. S.: Punj, S.K.: Singh, G. (2007). Influence of material parameters and thermal treatment on structure and properties of polyester airjet spun yarn. Indian Journal of Fibre and Textile Research, *32*, 150 – 157.
58. Moghassem, A. R.; Fakhrali, A. (2013). Comparative study on the effects of blend ration on tensile properties of ring and rotor cotton-polyester blended yarns using concepts of the hybrid effects. Fibre and Polymers, *14*(1), 157 - 165.

59. Shahid, M. A.; Mahabuzzaman, A. K. M.; Ahemed, F; Ali, A. (2016). Investigation of the physical properties of jute blended yarn using a novel approach in spinning process. Journal of Textile Science and Technology. *2*, 1 – 6.
60. Choudhuri, P. K.; Majumdar, P. K.; Sarkar, B. (2013) Studies on tensile properties of eri/acrylic blended yarn. Indian Journal of Fibre and Textile Research. *38*, 66 – 73.
61. Ramasamy, K. A.; Nalankilli, G.; Shanmugasundaram, O. L. (2014). Properties of cotton, tencel and cotton/tencel blended ring spun yarn. Indian Journal of Fibre and Textile Research, *39*, 322 – 325.
62. Baykal, P. D.; Babaarslan, O.; Erol, R. (2006). Prediction of strength and elongation properties of cotton/polyester blended OE rotor yarn. Fibre and Textile in Easter Europe, *14*, 18 – 21.
63. Tyagi, G. K.; Goyal, A.; Gon, D. P. (2007). Contributions of fibre profile to polyester-viscose and polyester – cotton ring and mjs yarn. Indian Journal of Fibre and Textile Research, *32*, 404 – 408.

Bibliography

64. Shaikh, T. N.; Bhattacharya, S. S. (2016). Engineering techniques of Ring spinning, Woodhead Publishing India Pvt Ltd, New Delhi.
65. Artificial Intelligence. Elaine Rich, Kevin Knight and Shivashankar B Nair. The McGraw-Hill Companies, Third Edition.
66. Artificial Intelligence: A Modern Approach, Stuart Russell and Peter Norvig. Pearson. Third Edition.
67. Machines of Loving Grace: The Quest for Common Ground Between Humans and Robots. John Markoff, Harper Collins Publishers.
68. Superintelligence: Paths, Dangers, Strategies. Nick Bostrom. Oxford University Press.
69. Life 3.0: Being Human in the Age of Artificial Intelligence. Max Tegmark. Vintage. Reprint 2018.
70. A Beginner's Guide to Artificial Intelligence: for Boomers and Boards. Brian Garr
71. Neural Networks for Pattern Recognition. Christopher M. Bishop. Oxford University Press.

72. Networks: A Comprehensive Foundation. Simon Haykin. Prentice Hall of India.
73. Neural Networks and Learning Machines. Simon Haykin. Prentice Hall of India.
74. Neural Networks and Statistical Learning. Ke-Lin Du , M. N. S. Swamy. Springer (2014).